AVAILABILITY OF SOIL POTASSIUM AS AFFECTED BY MULCHING WITH BLACK POLYETHYLENE PLASTIC

by

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INTRODUCTION AND REVIEW OF LITERATURE

Potassium has long been recognized as being important to crop production. Often referred to as the third fertilizer element, its importance was not fully realized until the last 30 to 35 years. Investigations concerning potassium and its availability to plants have led to many conclusions which at first seemed to be contradictory. Possibly soil potassium availability as affected by moisture and drying conditions has been studied the most extensively and produced the most contradiction of all of the investigations that have been conducted concerning this essential plant nutrient element.

It has long been known that exchangeable and soluble potassium present in certain soils not receiving potash applications would not be sufficient for maximum crop production over a great length of time. Before the advent of the concept of base exchange in soils, the immediate source of potassium was understandably attributed to the decomposition of minerals. It has been only comparatively recent that the interrelationships of exchangeable and released non-exchangeable K as they affect availability to plants have been extensively studied.

Several investigators, as early as 1915, found that potassium uptake by plants grown in soil which was treated in such way as to remove soluble and exchangeable potassium was often as great or greater than uptake from soils which were not so treated.

Reitemeier (1951) stated that one of the more common and

current methods of determining the amount of release on non-exchangeable potassium to exchangeable potassium was that of prolonged cropping. He noted that such studies have indicated that broad differences exist among the capacities of different soils to supply non-exchangeable K of native origin; soils of equal K content differ considerably in the availability of reserve K; fixed K is generally more available than native non-exchangeable forms; although release from some soils occurs when the exchangeable K level is relatively high, it is more likely to occur at lower levels therefore; the initial level of exchangeable K is not an accurate index of reserve supplying power unless it represents the equilibrium level for the particular soil; if the intensity and period of cropping is sufficient, the exchangeable K is reduced to a minimum value, and all subsequent release occurs at this exchange level; plants absorb more reserve K than is liberated to the exchangeable form in the absence of plants during moist storage for the same period of time; liming an acid soil generally increased the extent of release.

Steenkamp (1928) published data showing marked increases in exchangeable soil potassium as a result of drying. Since then many other investigators have observed the occurrence of this phenomenon in many soils. During this same period it was found that heating soils to various temperatures would also cause an increase in exchangeable K. Bray and DeTurk (1939) reported that heating soils to 200° C would release potassium when the initial exchange level was low. Oven-drying at 70° C of some

Indiana soils increased the exchangeable K over that in the moist state and in many cases doubled it according to Rouse and Bertramson (1950). Reitemeier et al. (1948) reported that after intensive cropping at the minimum exchangeable K level, several soils released K on air-drying and more on drying at 105° C. It was also established that the release mechanism in these soils was primarily a property of the clay fraction.

Because the definition of available potassium is so dependent on the vegetation and time factors, it is best to define fixed potassium as applied potassium which is not immediately replaceable by the usual cation exchange reagents as NH_4 acetate. This also brings the phenomenon of fixation to a relationship which is more consistent with the release of non-exchangeable potassium, both native and fixed.

In the first detailed study of fixation by soils, N. J. Volk (1934) observed relatively little fixation when soils were kept moist compared to that by drying at 70° C. DeTurk et al. (1943) observed K fixation in soils both under moist storage at ordinary temperatures and by drying at 200° C provided the initial value of exchangeable K exceeded the equilibrium level. Attoe (1947) showed that drying at room temperature of soils not fertilized with potassium resulted in an increase in content of exchangeable potassium in nine out of ten soils tested, the increases ranging from four to 90 per cent of that present in the moist soil. When these soils were fertilized with K and stored in the moist condition for two months, fixation occurred in eight of the ten soils; and when dried at room temperature,

fixation occurred in every case, the percentage fixed of that applied ranging from 11 to 52 per cent. Scott et al. (1957) found that on several Iowa soils, that normally released K on drying, a continuous net fixation of K on drying when enough KCl was added to the moist soil. The release of K was reduced when NH_4Cl, NaCl, or HCl was added to the soil prior to drying. The NH_4Cl additions were particularly effective. $CaCl_2$ additions had little or no effect on the K released by drying.

Fine and co-workers (1941) reported that with freezing and thawing conditions non-exchangeable potassium was often released, but in some cases fixation of exchangeable potassium took place.

Luebs et al. (1956) reported some potassium released on drying was reverted to a fixed or not readily exchangeable form on rewetting in various degrees. Hanway and Scott (1957) found that on several Iowa soils K was released in all cases on air drying, but relationship did not exist between the amount of K released and the amount of released K that reverted to fixed form when the soils were subsequently stored under moist conditions. There was more reversion of K to fixed form in the Marshall profile samples which indicated that greater reversion occurs in the least weathered material.

Hanway and Scott (1959) published data which indicated that K released on drying was reverted to some degree on rewetting of the soil but the amount of reversion was small in most cases. Reversion was greatest in the subsoil.

Effects of mulching on potassium availability have been

studied to a limited extent. Wander and Gourley (1938) found that under a heavy straw mulch over a period of 22 to 28 years on a Mahoning silty clay loam at Strongsville, Ohio that there was an increase in available potassium over that in plots which had either been clean cultivated or maintained in bluegrass sod. The increase in available K occurred to a depth of 24 to 32 inches in the profile. Stephenson and Schuster (1945) showed that heavy straw mulch on Willamette loam saved moisture equivalent to two or three inches of rainfall in dry weather. The moisture saving was principally in the upper two feet of soil. It was also shown that the mulch caused a marked increase in soluble K but little increase in Ca in the topsoil. Stephenson and Schuster (1946) published data which showed a great increase in the amount of available potassium in the surface soil. Fertilizer, however, had little effect on the amount of soluble K in any of the plots.

There is some question as to why the increase in available potassium under straw mulch. There was some belief that the potassium increase may have been caused by K being leached from the mulch, but Russell (1950) reasoned that since potassium was the only element which showed an increase in availability under mulch that this increase was probably a specific effect of the mulch due to some cause yet unrecognized. Russell also stated that a surface mulch of vegetative material such as straw has two types of effects on the soil: a characteristic effect, due to it being on the surface of the soil, and a general effect, which it would equally well have if it were plowed into the

soil, due to the plant nutrients set free as it decomposes. The primary specific effects of the mulch are confined to the superficial soil layers, which it keeps both cooler and at a more even temperature, and damper than the unmulched soil.

According to Reitmeier (1951) the various forms of soil potassium are interrelated. A change in one form occurs at the expense of one or more other forms of soil potassium. The availability to plants depends on the rate of release to the available forms from reserve supplies.

The main objective of this study was to ascertain the influence of mulching with black polyethylene plastic on potassium availability to plants. In order to accomplish this main objective it was necessary to determine (1) what effect, if any, such mulching had on moisture status of the soil, (2) what effect it had on exchangeable potassium content of the soil, (3) what effect it had on corn production, and (4) what influence it had on total potassium accumulation by the plants.

METHODS OF STUDY

Potassium fertility plots at Thayer and Columbus Experiment Fields in Southeastern Kansas were mulched with black polyethylene plastic in late June, 1960. The soil at this location is classified as Parsons silt loam. Plots which had received K treatments corresponding to 0, 90, and 150 pounds K_2O per acre at time of planting corn were so treated. A portion of each plot was covered with polyethylene, thus producing a split plot, one portion being mulched, the other portion unmulched. The

plastic, which was perforated every 12 inches to allow water to enter the soil, was placed between the corn rows and anchored with soil. The strips of plastic were pulled together as closely as possible around the corn stalks. Soil samples were taken from the top six inches and second six inches on July 20 and August 30. Samples were collected from the top six inches only on March 30 and April 3 at Columbus and Thayer fields, respectively. Moisture and exchangeable K content of the moist soil samples were then determined in the laboratory. At the time the August 30 soil sampling was made, plant samples were also taken. These samples were analyzed for K content and uptake of K was calculated.

For the determination of exchangeable potassium, 10 g. of moist soil which had passed a 10-mesh sieve were used. To this soil were added 50 ml of 1N ammonium acetate extracting solution. The solution and soil were then mechanically shaken for ten minutes and filtered. The filtrate was analyzed for potassium with a Beckman DU Spectrophotometer. Exchangeable K content of the soil samples was corrected for moisture which was present in the soil at sampling.

Potassium in the plant material was determined by the method suggested by Attoe (1947) with the exception that the Beckman spectrophotometer was used instead of the Perkin-Elmer flame photometer.

The potassium fertility plots upon which the polyethylene was placed originated in 1958 as part of a uniform experiment being conducted in the north central states. For the years

1958-1959 the plots received a blanket application of 80 pounds per acre of nitrogen (ammonium nitrate) and 120 pounds of available P_2O_5 (concentrated superphosphate). However, at Columbus corn plants on these plots became nitrogen deficient during the latter part of the 1959 growing season. Therefore, the rate of nitrogen was increased to 120 pounds per acre for the 1960 season (urea). This aided in preventing nitrogen deficiencies in 1960 but still may not have been enough to supply all of the nitrogen needed. All fertilizer was broadcast ahead of planting.

Plant growth and moisture content of the soil were hampered by droughty conditions during the months of July and August. In addition a late July hail storm virtually defoliated the corn at Thayer.

EXPERIMENTAL RESULTS

Data pertaining to moisture content of soil, exchangeable potassium content of soil, yields of grain and stover, and accumulation of potassium by plants were compiled and statistically analyzed. These data will be discussed separately in an attempt to show how mulching and fertilizer treatments affected these variables.

Moisture

Data from moisture determinations are given in Tables 1, 2, 3, 4, 5, and 6. It was found that mulching did not produce a significant difference in soil moisture content at the Thayer Experiment Field during the months of July or August (Tables 1

and 2). However, samples collected in April showed that moisture content of soil under mulch was appreciably greater than that in unmulched soil. These moisture amounts are shown in Table 3.

Moisture determinations made on samples from the Columbus Experiment Field showed that mulching had a significant effect on soil moisture conditions in the top six inches of the profile, as indicated by Tables 4, 5, and 6. At Columbus, mulching had not affected soil moisture amounts in the second six-inch layer at the time of the July sampling, but had produced differences by the time of the August sampling.

At each location, fertilizer treatments did not affect soil moisture.

Exchangeable Potassium

Samples from Thayer did not reflect significant differences between mulched and unmulched soils when analyzed for exchangeable potassium. These data, given in Tables 7, 8, and 9, seemed to reflect a pattern rather similar to that reflected by data collected with regard to soil moisture content.

Exchangeable soil potassium was not affected in July by mulching treatments at Columbus. These data are shown in Table 10. A significant difference was found between mulched and unmulched soil at this location at the time of the August sampling, but then only in the surface six inches. These data are shown in Table 11.

Table 1. Soil moisture content of mulched and unmulched soil at Thayer, July sampling.

Rate of K_2O	Moisture Content (%)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	12.42	11.43	11.92	17.29	20.09	18.69
90	10.92	10.06	10.49	17.66	18.38	17.90
150	12.10	11.86	11.98	18.51	17.46	17.98
Av.	11.81	11.12		17.82	18.56	
L.S.D.(.05)		ns	ns		ns	ns

Table 2. Soil moisture content of mulched and unmulched soil at Thayer, August sampling.

Rate of K_2O	Moisture Content (%)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	17.84	15.91	16.87	19.76	19.03	19.40
90	15.36	15.38	15.37	15.36	20.71	18.03
150	16.37	15.44	19.91	20.04	18.80	19.42
Av.	16.52	15.57		18.38	19.51	
L.S.D.(.05)		ns	ns		ns	ns

Table 3. Soil moisture content of mulched and unmulched soil at Thayer, April sampling.

Rate of K_2O	Moisture Content (%)		
	0-6"		
	Mulched	Unmulched	Average
0	20.13	13.01	16.57
90	20.17	14.86	17.52
150	20.50	14.74	17.62
Av.	20.27	14.21	
L.S.D.(.05)		.53	ns

Table 4. Soil moisture content of mulched and unmulched soil at Columbus, July sampling.

Rate of K_2O	Moisture Content (%)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	16.07	14.05	15.06	14.22	14.61	14.41
90	15.28	14.00	14.48	15.00	16.73	15.81
150	14.94	12.72	13.83	15.93	14.83	15.38
Av.	15.43	13.49		15.02	15.39	
L.S.D.(.05)	2.03		ns	ns		ns

Table 5. Soil moisture content of mulched and unmulched soil at Columbus, August sampling.

Rate of K_2O	Moisture Content (%)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	9.13	8.07	8.60	8.61	8.43	8.52
90	11.00	7.87	9.43	10.85	8.29	9.57
150	11.06	8.11	9.58	11.85	7.09	9.47
Av.	10.40	8.02		10.44	7.93	
L.S.D.(.05)	.92		ns	1.25		ns

Table 6. Soil moisture content of mulched and unmulched soil at Columbus, March sampling.

Rate of K_2O	Moisture Content (%)		
	0-6"		
	Mulched	Unmulched	Average
0	21.46	20.47	20.97
90	20.88	20.24	20.56
150	21.56	20.79	21.18
Av.	21.30	20.51	
L.S.D.(.05)	.65		ns

Table 7. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Thayer, July sampling.

Rate of K_2O	Exchangeable K (lbs./A)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	108	103	106	83	86	84
90	180	162	171	110	114	112
150	203	191	197	118	107	113
Av.	164	152		104	102	
L.S.D.(.05)	ns		36	ns		24

Table 8. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Thayer, August sampling.

Rate of K_2O	Exchangeable K (lbs./A)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	103	96	100	88	89	88
90	173	178	175	114	106	110
150	202	216	209	111	108	109
Av.	159	164		104	101	
L.S.D.(.05)	ns		24	ns		18

Table 9. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Thayer, April sampling.

Rate of K_2O	Exchangeable K (lbs./A)		
	0-6"		
	Mulched	Unmulched	Average
0	100	104	102
90	160	140	150
150	202	178	190
Av.	154	141	
L.S.D.(.05)	ns		42

Table 10. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Columbus, July sampling.

Rate of K_2O	Exchangeable K (lbs./A)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	97	96	96	72	64	68
90	132	142	137	75	78	77
150	165	173	169	98	88	93
Av.	131	137		82	77	
L.S.D.(.05)	ns		15	ns		16

Table 11. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Columbus, August sampling.

Rate of K_2O	Exchangeable K (lbs./A)					
	0-6"			6-12"		
	Mulched	Un-mulched	Average	Mulched	Un-mulched	Average
0	89	96	92	76	71	74
90	127	148	137	88	108	98
150	148	175	162	92	103	97
Av.	121	140		85	94	
L.S.D.(.05)	10		22	ns		13

Table 12. Exchangeable K in mulched and unmulched soil for different K_2O treatments at Columbus, March sampling.

Rate of K_2O	Exchangeable K (lbs./A)		
	0-6"		
	Mulched	Unmulched	Average
0	99	101	100
90	131	142	136
150	171	176	173
Av.	134	139	
L.S.D.(.05)	ns		32

It was observed that variations in amounts of exchangeable potassium as existed in the early spring of 1961 were not significant (Table 12).

As expected, fertilizer treatments did affect the amount of exchangeable potassium present. In all but one case the differences in exchangeable potassium recovered in the six to twelve inch portion of the profile were significant only between the zero and 90 pound per acre treatment with K_2O. Differences between the 90 and 150 pound treatments were not significant indicating a possibility of greater fixation of applied potassium as the rate of application was increased.

Different rates of fertilizer would not be expected to affect exchangeable potassium in the subsoil to any great extent, since fertilizer was applied to surface soil and very little mixing of the two layers took place during cultivation.

Yield of Corn and Stover

Corn yields, given in Tables 13 and 14, were not affected by mulching or fertilizer treatments. Field observations while corn was still in early ear stage of production indicated that the most vigorous plants were those on plots which had not received potash.

Results with stover, Tables 15 and 16, were very similar to results obtained for grain yields. Statistically, yield differences among treatments were not significant, however, a slight trend for larger yields with increased amounts of exchangeable potassium can be noticed.

Table 13. Yield of corn grain as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	Yield (bu/A)		
	Mulched	Unmulched	Average
0	75	86	80
90	91	80	86
150	96	70	78
Av.	84	79	
L.S.D.(.05)	ns		ns

Table 14. Yield of corn grain as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	Yield (bu/A)		
	Mulched	Unmulched	Average
0	107	91	99
90	86	86	86
150	86	96	91
Av.	93	91	
L.S.D.(.05)	ns		ns

Table 15. Yield of corn stover as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	Yield (T/A)		
	Mulched	Unmulched	Average
0	3.2	3.8	3.50
90	3.2	3.9	3.55
150	3.6	4.3	3.95
Av.	3.33	4.0	
L.S.D.(.05)	ns		ns

Table 16. Yield of corn stover as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	Yield (T/A)		
	Mulched	Unmulched	Average
0	3.6	3.9	3.75
90	4.3	3.9	4.10
150	3.8	4.3	4.05
Av.	3.9	4.0	
L.S.D.(.05)	ns		ns

Table 17. Per cent K in corn grain as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	Potassium (%)		
	Mulched	Unmulched	Average
0	.331	.326	.328
90	.326	.316	.321
150	.315	.328	.321
Av.	.324	.323	
L.S.D.(.05)	ns		ns

Table 18. Per cent K in corn grain as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	Potassium (%)		
	Mulched	Unmulched	Average
0	.343	.350	.347
90	.371	.372	.372
150	.369	.379	.374
Av.	.361	.367	
L.S.D.(.05)	ns		ns

Table 19. Per cent K in corn stover as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	Potassium (%)		
	Mulched	Unmulched	Average
0	1.153	1.024	1.088
90	1.574	1.614	1.594
150	1.708	1.698	1.703
Av.	1.478	1.445	
L.S.D.(.05)	ns		.22

Table 20. Per cent K in corn stover as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	Potassium (%)		
	Mulched	Unmulched	Average
0	.952	.809	.881
90	1.168	1.140	1.154
150	1.426	1.478	1.452
Av.	1.182	1.142	
L.S.D.(.05)	ns		.15

Table 21. K uptake by corn grain as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	K uptake (lbs./A)		
	Mulched	Unmulched	Average
0	18	20	19
90	21	18	20
150	18	16	17
Av.	19	18	
L.S.D.(.05)	ns		ns

Table 22. K uptake by corn grain as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	K uptake (lbs./A)		
	Mulched	Unmulched	Average
0	24	22	23
90	23	22	22
150	22	25	23
Av.	23	23	
L.S.D.(.05)	ns		ns

Table 23. K uptake by corn stover as affected by mulching and fertilizer treatments at Thayer.

Rate of K_2O	K uptake (lbs./A)		
	Mulched	Unmulched	Average
0	72	75	73.5
90	100	127	113.5
150	124	177	150.5
Av.	98	129	
L.S.D.(.05)	ns		27.4

Table 24. K uptake by corn stover as affected by mulching and fertilizer treatments at Columbus.

Rate of K_2O	K uptake (lbs./A)		
	Mulched	Unmulched	Average
0	68	64	66
90	102	89	96
150	112	134	123
Av.	94	96	
L.S.D.(.05)	ns		25.5

Potassium Uptake by Plants

Tables 17 and 18 show results obtained when grain was analyzed for potassium content. Per cent potassium in grain was not affected by any of the treatments. This held true for both fields. However, percentage of potassium in plant tissue was affected by fertilizer treatment as was more or less expected, but differences caused by mulch treatments were not significant. Tables 19 and 20 present data relative to percentages of potassium in non-grain portions of the plants.

Potassium accumulations by grain and non-grain portions of plant tissues are given in Tables 21 to 24. Amounts of potassium in grain, given in pounds per acre, did not vary significantly according to treatment. These data are given in Tables 21 and 22.

Tables 23 and 24 show potassium accumulations by non-grain portions of plant tissue in pounds per acre. These data, showing about the same results as those giving percentages of potassium in the plant, indicate differences among fertilizer treatments but not among mulching treatments. It was noticed however, that there was a tendency for greater potassium uptake at the Thayer location from unmulched soil than from the mulched portion.

DISCUSSION

As noted above, soil moisture levels were not significantly different during July and August at the Thayer experimental

field between mulched and unmulched soils. From the latter part of June, when the polyethylene mulch was applied until the second week of August, rainfall received at this location was usually in amounts of less than one-half inch. After this period of time, larger amounts of moisture were received. When amounts greater than one inch were received, they were usually in the form of heavy downpours and much of the moisture was lost due to runoff. Since the upper portion of the soil profile was dry at the time the mulch was applied, it could not be expected that moisture would be greater under the mulch than otherwise. During the winter and early spring, normal precipitation was received and soil moisture content beneath the mulch was appreciably greater than that in unmulched soil.

Moisture received at the Columbus field was more effective during the summer months as well as being about average for the winter and early spring period. Under conditions of adequate or nearly adequate moisture supply, it has been shown that mulching will affect soil moisture content.

It might have been assumed that fertilization could have affected soil moisture indirectly by causing more plant growth and thus a greater water utilization. Tables 13 to 16 show, however, that plant growth was not increased by additions of K_2O. Yield data collected over a three-year period for the same fertility plots have shown that 90 to 120 pounds per acre of K_2O should produce the largest increase in yield, but the three-year average indicates that only a three or four bushel increase over the check can be expected (Table 25). Thus having knowledge of

Table 25. Summary of yields for potash fertilizer trials with corn - Columbus and Thayer.

K_2O Lbs./A	Yield of Corn (bu./A)								
	Columbus				Thayer				Three year average, two locations
	1958	1959	1960	Average	1958	1959	1960	Average	
0	108.4	88.7	88.9	95.3	97.9	93.4	69.2	86.8	91.1
30	106.7	86.4	93.3	95.5	97.6	89.7	74.4	87.2	91.4
60	110.1	89.0	94.9	98.0	102.1	83.1	82.7	89.3	93.7
90	108.9	88.2	84.0	93.7	100.2	80.6	71.8	84.2	88.9
120	112.2	94.7	92.1	99.7	106.0	91.1	69.7	88.9	94.3
150	108.5	86.2	82.7	92.5	101.4	95.7	69.2	88.8	90.7

previous yields, the lack of significant differences between fertilizer or mulch treatments was not surprising.

From soil moisture data it is seen that when adequate rainfall has been received, mulching influences soil moisture conditions. From these data the assumption can be made that soil under mulch is held at a more constant moisture level than unmulched soil which is subjected to the natural dry-moist cycle found in the field.

Comparing exchangeable potassium present in mulched and unmulched soils used in this study, it has been shown that very little increases, if any, took place. There certainly was not an increase in available potassium under mulch as found by earlier investigators. This would lead one to believe that the increase in available potassium under straw mulches was due to potassium in the mulch itself and not to conditions produced by the mulch.

Data concerning exchangeable potassium shows some evidence that soil moisture is the principal factor regulating release of non-exchangeable potassium to the exchangeable form. It has been noted that mulching did not affect soil moisture during July and August at the Thayer field (Tables 1 and 2). It was then noted that mulching did not cause significant differences in exchangeable potassium for the same period at this location (Tables 7 and 8).

At the Columbus field where mulching produced differences in soil moisture content (Tables 10 and 11) during July and August, a significant difference was found between the mulched and

unmulched soils during the second sampling (Table 11).

It thus appears that if a soil is held constantly at a moisture content higher than that of soil subjected to natural drying and wetting, exchangeable potassium will be increased in the drier soil.

Release of non-exchangeable potassium through the winter months by freezing and thawing may also be regulated by moisture content of the soil at the time of freezing. In Tables 8 and 9 it is shown that exchangeable potassium in the soil during early spring is essentially the same as it was during late summer. This was at the Thayer location where the moisture contents of mulched and unmulched soil were the same. At Columbus it was shown that exchangeable potassium remained the same for the unmulched soils during the winter, however, soils under mulch had an increase in exchangeable potassium in the spring over the amount present in early fall. The moisture content of the mulched soil at Columbus was significantly higher than the unmulched soil thus indicating that freezing and thawing releases potassium at a faster rate when this soil is moist than when dry.

Potassium uptake by plants or yield data show inconsistencies as to the availability of potassium present in the soil.

SUMMARY AND CONCLUSION

In summarizing these results it was found that:

(1) Mulching soils with polyethylene plastic seemed to maintain soils at a greater moisture content if the

mulch was applied at a time when the soil moisture content was relatively high.

(2) Mulching soils under such conditions seemed to slow the release of non-exchangeable potassium to an exchangeable form. Evidence of this effect generally was not so striking as to be statistically significant, however.

(3) Non-exchangeable potassium may have been released faster as a result of freezing and thawing in moist soils than in dry soils. The magnitude of such release may have been about equal to that which would occur if soils were not held at a continuously high moisture content during the growing season but rather were allowed to follow the normal dry-moist cycle found in the field.

(4) There were some indications that the particular method of mulching used did not allow moisture to enter soil as easily as might be hoped for. Higher soil moisture content might result beneath the mulch if a shredded plastic material was placed in a layer over the soil rather than a sheet of plastic being placed over the surface of the soil.

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APPENDIX

Table 26. Analysis of variance for soil moisture content, 0-6 inch depth, Thayer, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	17.7985	8.8992
Replication	4	23.0938	5.7734
Error (a)	8	18.6601	2.3325
Subplot:			
Mulch	1	3.5400	3.5400
M x F	2	.8032	.4016
Error (b)	12	24.8021	2.0668

Table 27. Analysis of variance for soil moisture content, 6-12 inch depth, Thayer, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	3.7437	1.8718
Replication	4	42.2668	10.5667
Error (a)	8	41.5038	5.1879
Subplot:			
Mulching	1	4.1367	4.1367
M x F	2	4.8372	2.4186
Error (b)	12	20.4515	1.7043

Table 28. Analysis of variance for soil moisture content, 0-6 inch depth, Thayer, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	11.626	5.813
Replication	4	25.691	6.423
Error (a)	8	31.706	3.963
Subplot:			
Mulching	1	6.712	6.712
M x F	2	3.755	1.8775
Error (b)	12	78.584	6.549

Table 29. Analysis of variance for soil moisture content, 6-12 inch depth, Thayer, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	12.570	6.485
Replication	4	168.072	4.202
Error (a)	8	88.448	11.056
Subplot:			
Mulch	1	9.588	9.588
M x F	2	7.268	3.634
Error (b)	12	35.474	2.956

Table 30. Analysis of variance for soil moisture content, 0-6 inch depth, Thayer, April.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	6.6919	3.3460
Replication	4	1.5712	.3928
Error (a)	8	32.5352	4.0669
Subplot:			
Mulch	1	275.6695	275.6695**
M x F	2	4.4072	2.2036
Error (b)	12	53.6666	4.4722

L.S.D. (.05) = .53 between mulch treatments.

Table 31. Analysis of variance for soil moisture content, 0-6 inch depth, Columbus, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	9.0177	4.5089
Replications	5	43.7616	8.7523
Error (a)	10	52.7212	5.2721
Subplot:			
Mulch	1	33.9307	33.9307*
M x F	2	.6451	.3226
Error (b)	15	68.3247	4.554

L.S.D. (.05) = 2.03 between mulch treatments.

Table 32. Analysis of variance for soil moisture content, 6-12 inch depth, Columbus, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	12.3361	6.1680
Replication	5	46.6341	9.3268
Error (a)	10	113.8563	11.3856
Subplot:			
Mulch	1	1.2470	1.2470
M x F	2	12.9667	6.4833
Error (b)	15	137.2636	9.1509

Table 33. Analysis of variance for soil moisture content, 0-6 inch depth, Columbus, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	6.7310	3.3655
Replication	5	17.7097	3.5419
Error (a)	10	11.7032	1.1703
Subplot:			
Mulch	1	50.8607	50.8607**
M x F	2	7.8179	3.9090
Error (b)	15	24.4795	1.6320

L.S.D. (.05) = .92 between mulch treatments.

Table 34. Analysis of variance for soil moisture content, 6-12 inch depth, Columbus, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	8.0257	4.0128
Replication	5	44.6697	8.9339
Error (a)	10	47.5733	4.7573
Subplot:			
Mulch	1	56.1751	56.1751**
M x F	2	31.3435	15.6718
Error (b)	15	45.6465	3.0431

L.S.D. (.05) = 1.25 between mulch treatments.

Table 35. Analysis of variance for soil moisture content, 0-6 inch depth, Columbus, March.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	2.3630	1.1815
Replication	5	21.8171	4.3634
Error (a)	10	4.9867	.4987
Subplot:			
Mulch	1	5.6121	5.6121*
M x F	2	.2865	.1432
Error (b)	15	12.7421	.8495

L.S.D. (.05) = .65 between mulch treatments.

Table 36. Analysis of variance for exchangeable potassium, 0-6 inch depth, Thayer, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	11319.30	5659.65**
Replication	4	2409.68	602.42
Error (a)	8	2425.36	303.17
Subplot:			
Mulch	1	260.49	260.49
M x F	2	58.88	29.44
Error (b)	12	1173.11	97.759

L.S.D. (.05) = 36 between fertilizer treatments.

Table 37. Analysis of variance for exchangeable potassium, 6-12 inch depth, Thayer, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	1305.60	652.80
Replication	4	988.42	247.105
Error (a)	8	1652.81	206.601
Subplot:			
Mulch	1	3.08	3.08
M x F	2	99.75	49.875
Error (b)	12	515.13	42.93

L.S.D. (.05) = 24 between fertilizer treatments.

Table 38. Analysis of variance for exchangeable potassium, 0-6 inch depth, Thayer, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	15787.70	7893.85**
Replication	4	441.98	110.495
Error (a)	8	1064.86	133.1075
Subplot:			
Mulch	1	28.03	28.03
M x F	2	190.12	95.06
Error (b)	12	481.88	40.157

L.S.D. (.05) = 24 between fertilizer treatments.

Table 39. Analysis of variance for exchangeable potassium, 6-12 inch depth, Thayer, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	758.458	379.229*
Replication	4	860.025	215.006
Error (a)	8	662.025	82.7531
Subplot:			
Mulch	1	23.736	23.736
M x F	2	16.477	8.2385
Error (b)	12	266.522	22.2102

L.S.D. (.05) = 18 between fertilizer treatments.

Table 40. Analysis of variance for exchangeable potassium, 0-6 inch depth, Thayer, April.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	8591.85	4295.925**
Replication	4	2028.43	507.1075
Error (a)	8	3309.17	413.6462
Subplot:			
Mulch	1	320.14	320.14
M x F	2	1243.84	621.92
Error (b)	12	1410.74	117.5617

L.S.D. (.05) = 42 between fertilizer treatments.

Table 41. Analysis of variance for exchangeable potassium, 0-6 inch depth, Columbus, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	7832.727	3916.364**
Replication	5	1470.503	294.1
Error (a)	10	2046.460	204.646
Subplot:			
Mulch	1	76.854	76.854
M x F	2	60.882	30.442
Error (b)	15	1555.034	103.669

L.S.D. (.05) = 15 between fertilizer treatments.

Table 42. Analysis of variance for exchangeable potassium, 6-12 inch depth, Columbus, July.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	966.03	483.015*
Replication	5	526.42	105.284
Error (a)	10	731.38	73.138
Subplot:			
Mulch	1	54.03	54.03
M x F	2	78.13	39.06
Error (b)	15	841.81	56.12

L.S.D. (.05) = 16 between fertilizer treatments.

Table 43. Analysis of variance for exchangeable potassium, 0-6 inch depth, Columbus, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	7451.98	3725.99**
Replication	5	778.21	155.64
Error (a)	10	1454.77	145.477
Subplot:			
Mulch	1	758.08	758.08**
M x F	2	148.62	74.31
Error (b)	15	539.56	35.97

L.S.D. (.05) = 10 between mulch treatments.
L.S.D. (.05) = 22 between fertilizer treatments.

Table 44. Analysis of variance for exchangeable potassium, 6-12 inch depth, Columbus, August.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	1157.36	578.68**
Replication	5	813.36	162.67
Error (a)	10	503.43	50.343
Subplot:			
Mulch	1	175.12	175.12
M x F	2	235.69	117.84
Error (b)	15	1735.92	115.73

L.S.D. (.05) = 13 between fertilizer treatments.

Table 45. Analysis of variance for exchangeable potassium, 0-6 inch depth, Columbus, March.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	8103.39	4051.695**
Replication	5	1605.87	321.174
Error (a)	10	3148.97	314.897
Subplot:			
Mulch	1	74.83	74.83
M x F	2	25.04	12.52
Error (b)	15	1657.42	110.495

L.S.D. (.05) = 32 between fertilizer treatments.

Table 46. Analysis of variance for yield of corn grain, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	34878.9	17439.45
Replication	4	84462.83	21115.71
Error (a)	8	404085.8	50510.72
Subplot:			
Mulch	1	4838.4	4838.4
M x F	2	59926.7	29963.35
Error (b)	12	441803.4	36816.95

Table 47. Analysis of variance for yield of corn grain, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	66205.4	33102.7
Replication	5	403571.2	80714.24
Error (a)	10	193973.6	19397.36
Subplot:			
Mulch	1	40534.4	40534.4
M x F	2	29088.44	14544.22
Error (b)	15	297367.2	19824.48

Table 48. Analysis of variance for corn stover yield, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.43	.215
Replication	4	.86	.215
Error (a)	8	2.35	.294
Subplot:			
Mulch	1	.84	.84
M x F	2	.16	.08
Error (b)	12	3.74	.312

Table 49. Analysis of variance for corn stover yield, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.271	.1355
Replication	5	1.358	.2716
Error (a)	10	.936	.0936
Subplot:			
Mulch	1	.034	.034
M x F	2	.593	.2965
Error (b)	15	2.178	.1452

Table 50. Analysis of variance for per cent potassium in corn grain, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.00033	.000165
Replication	4	.00427	.00107
Error (a)	8	.00522	.00065
Subplot:			
Mulch	1	.00001	.00001
M x F	2	.00073	.000365
Error (b)	12	.01386	.001155

Table 51. Analysis of variance for per cent potassium in corn grain, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.0055	.00275
Replication	5	.0035	.00070
Error (a)	10	.0209	.00119
Subplot:			
Mulch	1	.0004	.0004
M x F	2	.0001	.00005
Error (b)	15	.0204	.00136

Table 52. Analysis of variance for per cent potassium in corn stover, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	2.14897	1.0745**
Replication	4	.28777	.0719
Error (a)	8	.35254	.0441
Subplot:			
Mulch	1	.00825	.00825
M x F	2	.03753	.01876
Error (b)	12	.19039	.01587

L.S.D. (.05) = .22 between fertilizer treatments.

Table 53. Analysis of variance for per cent potassium in corn stover, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	1.9609	.9804**
Replication	5	.2907	.0581
Error (a)	10	.4060	.0406
Subplot:			
Mulch	1	.0143	.0143
M x F	2	.0580	.01683
Error (b)	15	.2524	.01683

L.S.D. (.05) = .15 between fertilizer treatments.

Table 54. Analysis of variance for potassium uptake by corn grain, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.4508	.2254
Replication	4	1.3689	.3422
Error (a)	8	4.3619	.5452
Subplot:			
Mulch	1	.0580	.0580
M x F	2	.5571	.2786
Error (b)	12	4.3568	.3631

Table 55. Analysis of variance for potassium uptake by corn grain, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.4146	.2073
Replication	5	4.0400	.808
Error (a)	10	4.0232	.4023
Subplot:			
Mulch	1	.0230	.0230
M x F	2	.5749	.28745
Error (b)	15	3.7026	.24684

Table 56. Analysis of variance for potassium uptake by corn stover, Thayer.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.00211140	.001055700**
Replication	4	.00060994	.000152485
Error (a)	8	.00039485	.000049356
Subplot:			
Mulch	1	.00041367	.000413670
M x F	2	.00021815	.000109075
Error (b)	12	.00218906	.000182521

L.S.D. (.05) = 27.4 between fertilizer treatments.

Table 57. Analysis of variance for potassium uptake by corn stover, Columbus.

Source of variation	Degrees of freedom	Sum of squares	Mean square
Whole plot:			
Fertilizer	2	.001382683	.00069134**
Replication	5	.000598053	.00011961
Error (a)	10	.000566497	.00005665
Subplot:			
Mulch	1	.000001313	.00000131
M x F	2	.000148377	.00007419
Error (b)	15	.003862	.00025747

L.S.D. (.05) = 25.5 between fertilizer treatments.

AVAILABILITY OF SOIL POTASSIUM AS AFFECTED BY MULCHING WITH BLACK POLYETHYLENE PLASTIC

by

DON FRANKLIN WAGNER

B. S., Kansas State University, 1960

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In June, 1960, black polyethylene plastic was placed on potassium fertility plots at the Thayer and Columbus Experimental Fields located in Southeastern Kansas. Soil samples were collected from the mulched and unmulched portions of the plots. Moisture content and exchangeable potassium were determined on these samples. At the time of maturity plant samples were taken and percentage of potassium present in grain and non-grain portions was determined. Yield data were also collected. All data pertaining to the above determinations were then statistically analyzed.

Experimental data showed that mulching with polyethylene plastic will maintain a higher soil moisture level than that in soil subjected to natural conditions found in the field. It was noticed, however, that when this mulch was placed on soil which was relatively dry, moisture conditions were not altered to any great degree until a fairly large amount of effective rainfall was received.

Exchangeable potassium generally was not affected by mulching treatments during the course of this particular experiment. There were indications, however, of a trend toward higher exchangeable potassium content in unmulched soils which also had a lower moisture content over a period of time.

Potash fertilizer application affected the amount of exchangeable potassium in the soil. There was not an indication of a difference in behavior of applied potassium and that native to the soil insofar as effects of mulching were concerned, however.

Potassium uptake by corn grain was not affected by mulching or potassium applications. Non-grain portions of the corn plants did show an increase in potassium uptake as the rate of potash application was increased, but did not reflect an influence of mulching treatment.

In conclusion, data compiled over the duration of this experiment indicated that polyethylene mulching did not affect potassium availability in the soil. However, low rainfall which was generally experienced during the months of July and August, may have had an abnormal influence. The dry condition experienced during this time was detrimental to crop production and may have created a soil situation that did not allow for maximum effect of mulching. For these reasons, more study is needed before definite conclusions can be made with respect to the influence of mulching on potassium availability in soil.